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Packing and stents in endonasal surgery*

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SUMMARY

Nasal packing is used primarily to control bleeding in epistaxis and after surgical procedures to the nose such as septoplasty, turbinate and paranasal sinus surgery. It is also used for internal stabilisation after operations involving the cartilaginous-bony skeleton of the nose. Apart from haemostasis, packing is used to prevent synechiae or restenosis, particularly after surgery. Generally accepted standards regarding the materials which should be used for packing, how long the packing should be left in place or the indications for nasal packing are lacking (Egelund and Jeppessen, 1992; Hosemann, 1996; Weber et al., 1996b). For example, many authors do not use packing at all provided that there is no heavy bleeding during or after the operation. Of those who use packing, some remove it on the day of the operation, others up to 5 days postoperatively (for overview see Weber et al., 1996b). Most publications describe experience with packing materials developed or preferred by the authors. Results of comparative studies on the nature and duration of packing are listed in Table 1. The currently available materials are reviewed and their respective properties, indications and risks are outlined.

Key words: endonasal surgery, nasal packing, nasal stent, septoplasty, sinus surgery

1. MATERIALS

1.1. Ribbon gauze packing

This consists of an open-mesh *cotton gauze* as carrier material. Differences exist with regard to the width of the strips, the mesh size and the fabrication of the thread. The cotton gauze may be used as it is or it may be impregnated by the user with some form of medication, usually simple soft paraffin, a mixture of oily substances, or an antibiotic ointment.

The ointment component allows the gauze to slide more easily and prevents adherence to tissue while the antibiotics are intended to prevent infection. In many cases industrially medicated or impregnated gauze packs are used. *BIPP* (Bismuth Iodoform Paraffin Pack), mainly used in the United Kingdom, is impregnated with liquid paraffin and also contains iodoform and bismuth in a ratio of 2:1.

Bismuth is used because of its presumed bactericidal action, although this action is disputed (Nigam et al., 1990). *Telfa* (Kendall, Boston, USA; Kamer and Parks, 1975) has been adopted for nasal packing from surgical wound care and consists of a layer of cotton fleece enclosed in a perforated inert water-repellent plastic film.

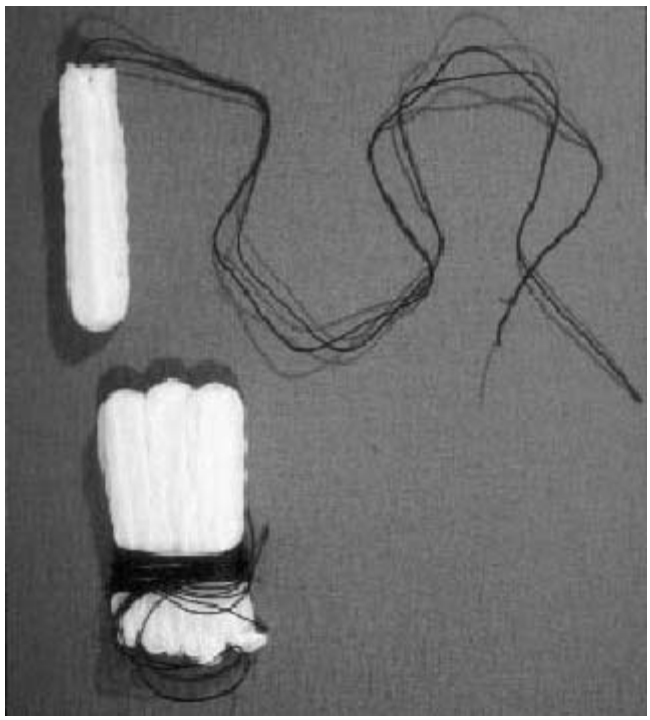

Figure 1: Rubber fingerstall packing (Rhinotamp, Vostra, Aachen, Germany).

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Table 1: Comparative studies on nasal packing (selection). add. = additionally

Ref.	Indication	Material	Duration	N	Result
Garth and Brightwell 1994	Septal/ tubinatie surgery	Telfa, parafffin gauze, Merocel, BIPP, add. Silastic splints	16-23 hours	48	Patient comfort: no difference, Ease of removal: Telfa > Gauze > BIPP > Merocel; Bleeding: Merocel > Gauze > BIPP > Telfa
Illum et al. 1992	Septal/ turbinate surgery	Fingerstalls, gauze with ventilation tubes, Merocel	3 days	82	Ease of removal: Fingerstalls > Gauze > Merocel; Nasal patency after 3 months: no difference; Postoperative Fever: Fingerstalls > Gauze/ Merocel; Merocel: 3 septal perforations; Ventilation tubes: no advantage
Von Schoenberg et al. 1993	Septal/ turbinate surgery	Telfa, BIPP, no packing, silastic splints (N=46)	24 hours	95	Pain on removal: BIPP > Telfa, Adhesion rate: no difference; Pain: Packing > no packing; BIPP + splints: 2 septal perforations
Watson et al. 1989	Septal/ turbinate surgery, polypectomy	Pneumatic balloon, gauze (Jelonet), fingerstalls, silastic splints	24 hours	106	Bleeding: no difference; nasal obstruction, fibrin accumulation, adhesion rate: balloon > Gauze > fingerstalls
Saab and Randell 1997	Epistaxis	Merocel, BIPP		30	Effectiveness: no difference; Ease of insertion and removal: BIPP > Merocel
El-Silimy 1993	Turbinate surgery	Gauze, no packing	24 versus 48 hours	180	Bleeding rate: 11.7% / 8.3% / 0% (48h / 24h / -); adhesion rate: no difference
Sirimanna et al. 1994	Turbonate surgery	Alginate, gauze, fingerstalls	24 versus 48 hours	92	Bleeding rate: gauze > fingerstalls > alginate and: 48 hours < 24 hours
Guyuron 1989	Septorhino-plasty	Paraffin gauze, no packing		50	Nasal breathing, residual septal deviation, synechiae: each superior results with packing than without packing

1.2. Fingerstall packs (Figure 1)

Fingerstall packs are made of latex rubber packed with foam or occasionally with gauze. They were introduced by Helms senior (Helms, 1977). Hospitals sometimes used to make these fingerstall packs themselves. Now, for reasons of quality and safety, commercially fabricated products are usually used. e.g. *Rhinotamp* (Vostra, Aachen, Germany). Differences in the manufacturing processes of the fingerstall packs affect particularly the quality of the latex and its allergenic activity. The pore size of the latex is extremely small preventing ingrowth of viruses or bacteria (Gerhardt, 1989; Zbitnew et al., 1989).

1.3. Foam packing and cellulose

Chemically, these packing materials are very different the one being derived from natural cellulose, the other a purely synthetic product (Table 2). However, their principles of action and use are closely related. In the dry state the packs are considerably smaller than after hydration at the site of action in the nose (Figure 2). Uptake of water or blood causes a rapid increase in volume thus leading to absorption of fluid and at the same time to wound compression. Newer fabrications are coated with a thin plastic film to smoothen the surface and, depending on the pore size, to avoid the ingrowth of granulation tissue.

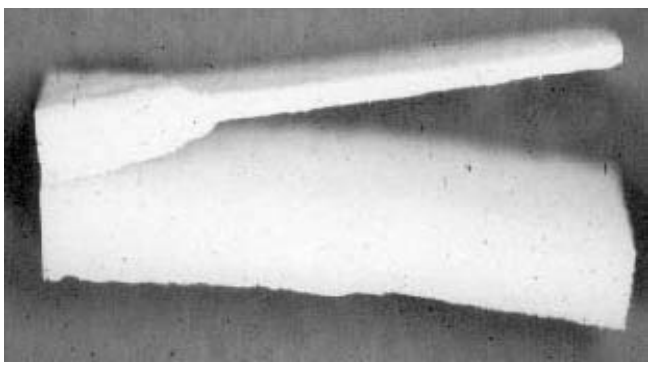

Figure 2: Foam packing: above under dry condition, below moistened; (Sugomed, Kettenbach, Eschenburg, Germany).

Cellulose packing

Cellulose generally refers to the polysaccharides widely present in nature in the walls of plant cells. It is extremely hygroscopic and swells in water and lyes. Tibbels first described the use of oxidised regenerated cellulose in epistaxis (Surgicel) in 1963. *Surgicel, Oxicel* (Fanous 1980) or *Tabotamp* (Johnson & Johnson, Norderstedt, Germany) are used nowadays not as routine nasal packing but as hemostypticum or for stabilisation of duraplasties.

1.4 Others

Special packings which were described by individual authors are: Vigilon (CR Bard, Burkley Heights, New Jersey, USA; Salassa and Pearson, 1991; Salassa, 1992) consists of a colloidal suspension of irradiated polyethylene oxide (4 %) and water (96 %). It comes in the form of a transparent, gelatine-like sheet one millimetre thick, covered by two layers of thin occlusive polyethylene film. The gel is permeable to water, oxygen and carbon dioxide, can take up twice its weight in fluid and is non-adherent.

Alginate pack Kaltostat (Sirimanna, 1989) consists of alginic acid, which is a natural substance obtained from brown seaweed. Reaction of potassium or calcium with the carboxyl group produces the corresponding alginate. Calcium alginate has haemostatic action by giving off calcium ions.

Table 2: Foam packing (selection).

Tradename	Components	Form and size
Merocel	Polyvinylacetal	Available in many forms and sizes
Merocel 2000 laminated	Additional coating with polyethylene	Available in many forms and sizes
Sugomed	31.3% cellulose + 68.7% viscose	Larger plates or stripes which could resterilized
Hydrocell	Polyurethane	Available in many forms and sizes, Pore size 0.005-0.020 mm
Expandacell	Polyvinylalcohole	Available in many forms and sizes, Pore size 0.23 – 0.99 mm
Stip	Vinylpolymere	Larger stripes
Ivalon	Polyvinylacetal	Available in many forms and sizes

Table 3: Use of stents in paranasal sinus surgery (selection).

Author	Stent	Site	Duration
Amble et al. 1996	silicone strips	Frontal sinus (Lynch-operation)	6-8 weeks, sometimes longer
Kaschke and Behrbohm 1997	Nasal splint with oval support surface at the nasal septum and a channel for the inferior aspect of the middle turbinate	Middle nasal tubinate	1-2 weeks
Brennan 1996	U-shaped polyurethane glove (Boomerang)	Middle nasal turbinate	14 days
Bumm 1980	Plastic, collar button	Maxillary sinus, inferior nasal meatus	6 weeks
Christmas and Krouse 1996	Gelfilm	Ethmoid sinus	2 weeks
Deitmer et al. 1988	Silicone	Frontal sinus (palpebral incision)	average 122 days
Duplechain et al. 1991	Silastic disk bent to form a V	Ethmoid sinus, children	3 weeks
Hoyt 1993	Plastic tube	Frontal sinus ostium	approximately 8 weeks
Lusk and Muntz 1990	Silastic stent, Gelfilm	Ethmoid sinus	7-10 days, 2-3 weeks
Messingschlager 1981	Plastic, collar button	Maxillary sinus, inferior meatus	2 months
Milewski 1996	Ethmo balloon catheter	Ethmoid sinus	1-2 weeks
Neel et al. 1976, 1987	Silicone strips, silicone tubes	Frontal sinus (Lynch-operation)	6-8 weeks
Parsons and Chambers 1995	Gelfilm	Ethmoid sinus	2 weeks
Rains 1997	Rains frontal sinus stent	Frontal sinus	3 weeks until ethmoid healed and oedema decreases
Rubin et al. 1986	Polyethylene tubes	Frontal sinus (palpebral incision)	5 months
Schaefer and Close 1990	Silicone catheter	Frontal sinus	6 weeks
Shikani 1994	Silicone	Maxillary sinus, middle meatus	10-14 days
Shikani 1996	Silicone	Maxillary sinus, middle meatus	10-14 days
Stammberger 1993	Polyethylene tube	Frontal sinus (palpebral incision)	3-6 months
Toffel 1995	Silastic stent + Merocel	Ethmoid sinus	1 week
Weber et al. 1996, 1997	Special silicone spacer	Frontal sinus ostium	6 months

Table 4: Use of stents in paranasal sinus surgery (according to a survey of 1997 with data from 116 hospitals in Germany).

Property criteria	Frequency of use of stents	Silicone/ polyethylene tubes
Endonasal frontal sinus surgery	29 (25%)	19 (66%)
Frontal sinus surgery via external approach	83 (72%)	62 (75%)
Middle meatal antrostomy	11 (9%)	3 (27%)

Carr and Gabriel (1985) reported effective control of epistaxis in platelet function disturbance with nasal packing obtained from fatty tissue of slaughtered pigs. They reported that the packing was easy to remove and did not adhere to the mucosa.

Gelfoam (Gelfilm) is an absorbable gelatine sponge which is obtained from pure refined gelatine. It absorbs blood in its mesh and liquefies completely after 2-5 days (Fanous, 1980). On account of its self-disintegration removal is not necessary. It should be mentioned that gelatine has been found to lead to increased postoperative formation of granulation tissue and subsequent scar formation (ear surgery: Hellström et al., 1983; lacrimal system surgery: Mauriello and Vadehra, 1996; sinus surgery: Tom et al., 1997).

1.5 Stents

Stents are devices made of exogenous materials different from the packing materials described above which are inserted in the nose following nasal or paranasal sinus surgery. On account of their shape and spatial configuration, they are used to keep wound surfaces apart, prevent stenosis and adhesions and, last-

ly, to influence wound healing. The devices are sometimes also referred to as 'spacers'. The stents used in nasal and paranasal sinus surgery must be distinguished from the mesh-like, self-expanding hollow devices used in cardiology and gastroenterology. They should also be distinguished from septum splints, with and without ventilation tubes, which are often used together with antibiotic-impregnated gauze packing and left in place for a few days. In practice, however, the three terms are often used interchangeably. In the following text we therefore follow the usage of the respective authors or manufacturers.

In general the foreign materials are used in endonasal surgery either to achieve good adaptation of the septal mucosa, to prevent formation of a haematoma or to minimise or prevent adhesion of wound surfaces and stenosis due to scarring. The spacers are also reported to accelerate the healing process by preserving the ventilation of the paranasal sinuses (Amble et al., 1996; Duplechain et al., 1991; Hoyt 1993). The continuous drainage of wound secretions is also reported to lead to better healing (Shikani 1994, 1996). Stents are used in varying lengths of time ranging between two weeks and six months after sinus surgery (Weber et al., 1996b, 1997). The literature on stents consists almost entirely of uncontrolled experience reports. An overview is given in Table 3. There are some recent prospective investigations showing an advantage by using stents (Table 3; Shikani, 1994, 1996; Weber et al., 1997).

The simplest form of spacer is a polyethylene or *silicone tube* which is secured with a suture to prevent dislocation. This is usually done with a non-resorbable suture through the anterior nasal septum or the side of the nasal vestibule. In Germany this is the most common type of spacer used in paranasal sinus surgery (Table 4).

Regarding stents for *inferior meatal antrostomy* (Bumm, 1980; Messingschlager, 1981), it should be noted that inferior meatal antrostomy has now been largely abandoned (Stammberger, 1998).

Stents for *middle meatus antrostomy* have been described by Shikani (1994, 1996) (Shikani Stent, Spiggle & Theis, Dieburg, Germany) and Weber et al. (1996b) (prototype made by Vostra, Aachen, Germany). The construction principle is the same for all products. They consist of a central ventilation tube which ensures ventilation and drainage of the maxillary sinus and acts as spacer to keep the newly created ostium patent. Flanges facing inwards and outwards automatically hold the spacer in the desired position (Figure 3). The devices are made of silicone. There are some differences with regard to the configuration of the flanges. Here the Vostra prototype deliberately has a larger surface for apposition to the lateral nasal wall which is more severely traumatised in this region by the operation. The resulting occlusive wound treatment promotes wound healing and is also intended to prevent formation of synechiae between the wound surface and the middle nasal turbinate. There are wide variations in the recommended times for leaving the spacer in situ: 2 weeks for the Shikani stent, compared with the 6 months recommended by Weber et al. (1996b) in order to allow a sufficient length of time to cover the phase of scar formation. All these stents are usually easily removed by endoscopically controlled extraction with nasal forceps without further local anaesthesia. Problems while the spacer is in situ can occur as a result of crust formation which can lead to occlusion of the central ventilation tube. Further, an unpleasant odour can occur if there is significant bacterial colonisation of the crusts. Large crusts can also impair the patency of the nose.

In a prospective study in 50 patients Shikani (1994) inserted a spacer in the middle meatal antrostomy for 10-14 days on one side but not on the other. All patients were given antibiotics for at least one month. Local postoperative care included nasal humidification and a nasal steroid spray. After a follow-up period of 3-18 months, with a mean of 8.2 months, 8 patients had complete occlusion of the stent lumen with crusting and 22 had partial occlusion with crusting; however, there were no associated clinical symptoms. At the time of removal 2 patients had minor adhesions on the spacer side while 18 % had significant adhesions on the control side. After removal of the spacer there was often a certain amount of granulation tissue around the spacer which subsided gradually and had disappeared after 10 days.

Shikani (1996) performed endoscopic paranasal sinus surgery in 40 children with randomised insertion of a stent on one side in 20 patients, and on both sides in 20. The stents were left in situ for 2 weeks in both cases. Further postoperative treatment consisted of nasal humidification and administration of a steroid spray and antibiotics for at least one month. 9.6 months postoperatively (range, 4-26 months) adhesions were present on the control side between the middle turbinate and lateral nasal wall in 55 % and between the septum and inferior nasal turbinate in 5 %. In 3 of these cases the adhesions were mild, in 5 cases

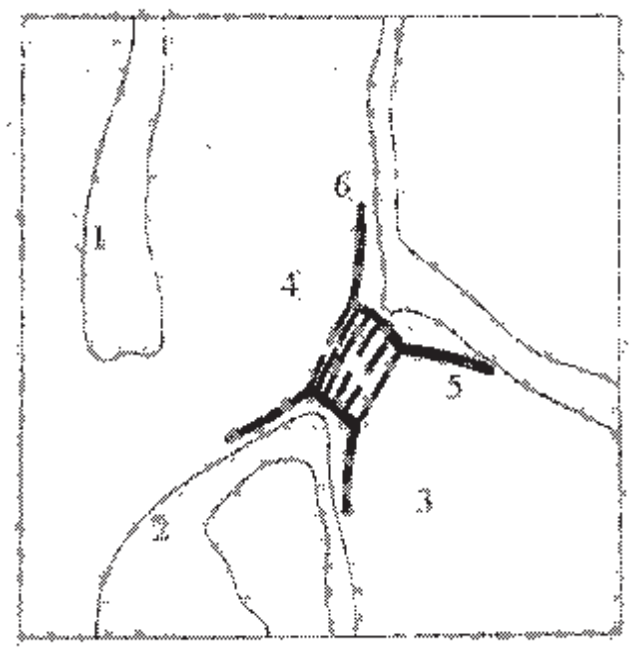

Figure 3: Stent for middle meatal antrostomy (principle)
1 = middle turbinate, 2 = inferior turbinate, 3 = maxillary sinus, 4 = stent with central perforation, 5 = Flanges inside the maxillary the sinus, 6 = Flanges outside for apposition to the lateral nasal wall

moderate and in 3 cases there was complete occlusion of the antrostomy. Two of these three patients required revision surgery. On the spacer side adhesions were only present in 10 % and were mild in one case, moderate in the other. In the group of 20 children with stenting on both sides revision surgery was only necessary in one case. Children under 7 years had a higher rate of postoperative synechiae and formation of granulation tissue (59 % versus 36 %).
Escajadillo (1991) described a silicone stent for middle meatal antrostomy (Silastic grommet device, Dow Corning, MI, USA) which was left in situ for two months. Six-12 months after insertion of the stent in 20 patients all had a wide, patent and functioning antrostomy compared with only 7 out of 10 cases in which the stent was not used.

In the *ethmoid sinus and the middle turbinate* Gelfilm, which is resorbed after about one week, is sometimes used as packing. This cannot strictly speaking be called stenting. Toffel (1995) used a special silicone sheet together with Toffel Merocel pack for one week under antibiotic cover with cephalosporins. After combined endoscopic paranasal sinus surgery and rhinoplasty 41 of 1363 patients had synechiae between the middle turbinate and lateral wall 1 to 3 years postoperatively. Revision surgery was necessary in 15 cases. Lusk and Muntz (1990) inserted a silicone sheet for 7 - 10 days and Gelfilm for 2 - 3 weeks. Thirty-one children were operated on and given additional antibiotics for more than 4 weeks. At least one year postoperatively 71 % of the parents reported that their children were well again.
Duplechain et al. (1991) used a silastic disk folded into a V which was inserted postoperatively into the ethmoid sinus in children and left in place for 3 weeks. They reported a lower incidence of development of synechiae in the ostiomeatal complex using this technique (no concrete figures given). The splints were removed at a second operation for cleansing the nose. Bernal-Sprekelsen (1990) described a new splint made of polypropylene (Prömeda, Niedernhausen, Germany) for use in surgery of the nasal septum, in some cases with reduction of the inferior turbinate or endoscopic ethmoidectomy. The splint is folded and inserted into the nasal cavities as inverted V and left in place for 4-10 days secured with vicryl sutures.
The Ethmo balloon catheter (Spiggle & Theis, Dieburg, Germany, Figure 4) is an anatomically shaped balloon made of medical grade silicone with a straight, dacron reinforced, non-elastic surface for support of the anterior skull base which is used for postoperative packing of the ethmoid shaft or the frontal recess (Milewski, 1996).
The U-shaped polyurethane glove (Boomerang Turbinate Glove, Westmed, Tucson, AZ, USA, Figure 5) for lining the middle nasal turbinate and septal splinting is secured to the contralateral side with a suture and left in place for about 2 weeks (Brennan, 1996). Brennan reports only one case of slight and two cases of moderate adhesions with the lateral nasal wall amongst 234 patients undergoing various forms of ethmoidectomy. Primed (Figure 6) is a similar product combining U-shaped lining of the middle nasal turbinate with septal splinting (Kaschke and Behrbohm 1997).

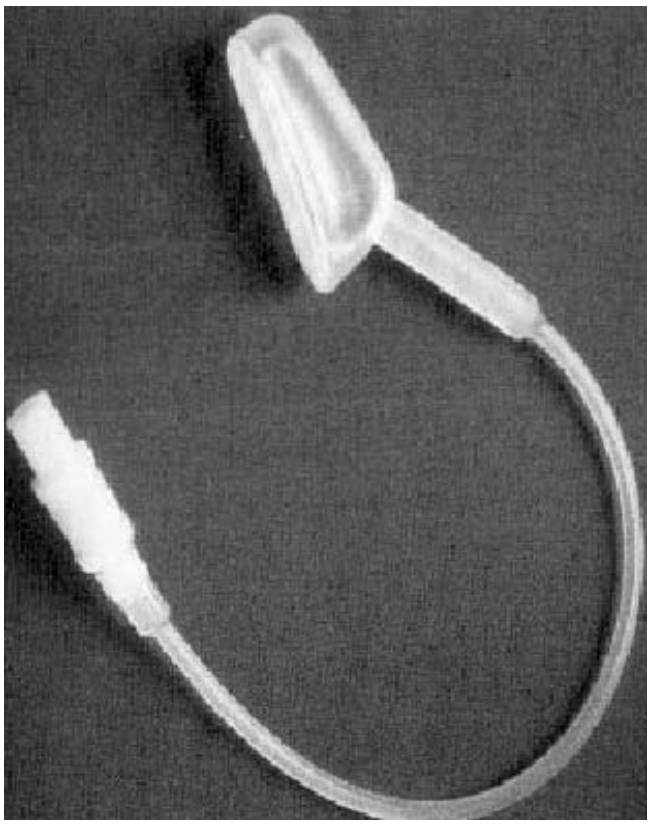

Figure 4: Ethmo Balloncatheter (Spiggle & Theis, Dieburg, Germany).

Figure 5: Boomerang Turbinate Glove (Westmed, Tucson, AZ, USA; Xomed, Garching, Germany).

For the *frontal sinus* Amble et al. (1996) recommend that a silicone sheet should be cut to shape, rolled up and inserted in the nasofrontal duct from outside. However, this calls for an external approach. The same applies to the polyethylene tube splayed at the frontal sinus by incision, heating and cooling the end as reported by Stammberger (1993).
Hoyt (1993) describes the endonasal insertion of a ventilation tube into the frontal sinus which is anchored to the anterior nasal septum with a Vicryl suture. Thirty-two tubes were inserted in 21 patients and left in place for mean duration of 8.3

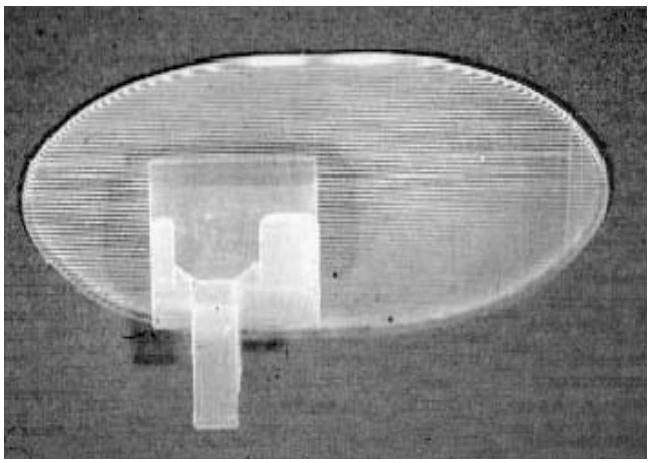

Figure 6: Primed Stent (Primed, Halberstadt, Germany)

Figure 7: Frontal sinus stent, prototype (Vostra, Aachen, Germany).

weeks. The indications were acute or chronic frontal sinusitis, with at least one previous operation and marked frontal sinus pathology in the CT. After a short not further specified follow-up period a failure rate of 9.5 % was given.

Modern frontal sinus stents are specially shaped so as to obviate the problem of dislocation by use of self-anchoring mechanisms. For example, the Vostra prototype has a large anchor ring in the frontal sinus (Weber and Keerl, 1996; Weber et al., 1997; Figure 7). A study conducted by the present authors is the only comparative study investigating the use of stents in frontal sinus surgery to date. Weber et al. (1997) performed a prospective study in 2 patient groups with surgery on a total of 36 paranasal sinus systems. In the context of an endonasal pansinus operation with type II extended frontal sinus drainage (Draf, 1991) because of chronic polypoid sinusitis a silicone stent was inserted for 6 months in 15 cases. Twelve-16 months postoperatively an endoscopically patent frontal sinus was found significantly more often after use of a stent (80 % versus 33 %), stenosis due to scarring was found in 6.7 % compared with 48 % ($p = 0.416$). The Rains frontal sinus stent has a widened end in the form of a compressible basket (Rains, 1997; Figure 8). The Parell T-stent is formed like a T (Figure 9). An alternative method used by the first-named author in four cases is transseptal insertion of a silicone tube which is particularly suitable for revision surgery, when there is a large wound area between the ethmoid shaft and the frontal sinus which has to be splinted. Type III frontal sinus drainages were kept open with tubes cut to form an H.

2. RISKS AND COMPLICATIONS OF NASAL PACKING AND STENTS (TABLE 5)

2.1. Mucosal lesions including septal perforation

Mucosal damage of this kind occurs when the pressure exerted by the packing exceeds the perfusion pressure of the nasal vessels for a prolonged period. Balloon catheters are particularly hazardous as the pressure exerted on the mucosa is difficult to dose and to judge. Klinger and Siegert (1997) studied the perfusion of the septal mucosa after balloon tamponade by laser-doppler flow measurement in 15 subjects and showed that the septal mucosa was no longer perfused at low pressures on the mucosa (mean pressure of 42 mm Hg) while at the same time the pressure measured within the balloon was ten times higher on account of the strong recoil force. Such damage is not likely to occur with normal nasal packing after endonasal surgery using fingerstalls or expandable packs. Small mucosal lesions as a result of ingrowth of tissue into the packing material when large-pore materials are used (gauze ribbon, expandable materials) are however possible and heal uneventfully in the large majority of cases.

2.2. Dislocation with possible aspiration

Posterior dislocation of ribbon gauze is possible and leads to an immediate foreign body sensation so that the pack must be completely removed from the nose. As the ribbon gauze does not shift en bloc there have been no reports of acute emergencies due to airway occlusion. However, gauze packing hanging down as far as the larynx can cause a sensation of choking (Yanagisawa and Latorre, 1995). On the other hand posterior dislocation of a fingerstall pack can lead to aspiration and complete occlusion of the laryngeal aperture or the trachea with the consequence or risk of acute asphyxiation. Thus Spillmann (1981) describes 2 deaths due to postoperative aspiration of fingerstall packs which were probably not anchored. It is therefore important to ensure that fingerstall packs are appropriately secured. In the case of Rhinotamp the manufacturers (Vostra, Aachen, Germany) recommend that bilateral packing should be used and the drawstrings knotted together in front of the anterior nasal septum and secured to the bridge of the nose with two strips of tape. While posterior dislocation was still observed in some cases when the drawstrings of bilateral packs were only

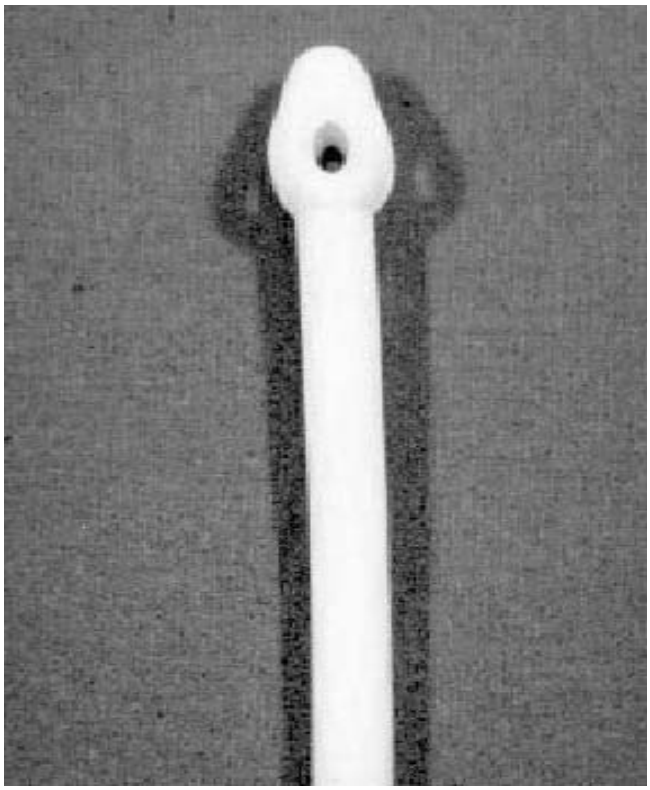

Figure 8: Rains frontal sinus stent (Smith & Nephew, Schenefeld, Germany)

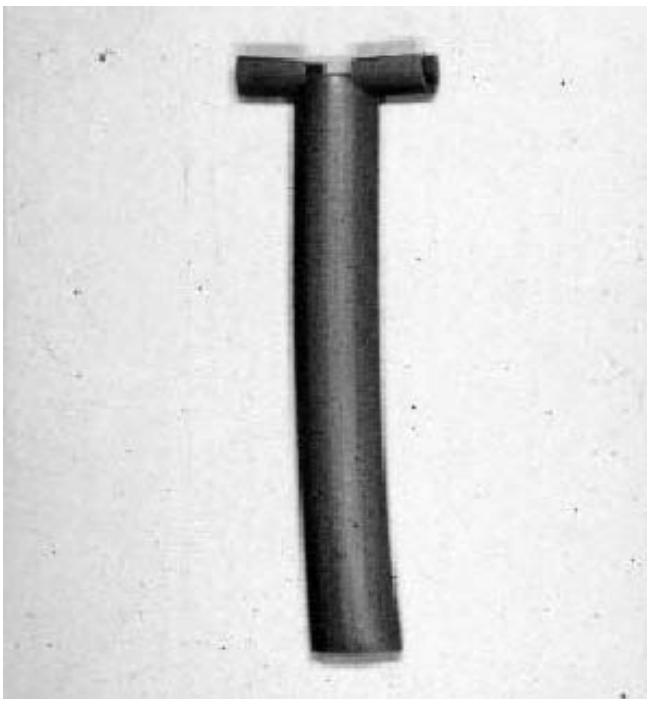

Figure 9: Parell T stent (Xomed, Garching, Germany).

plaited together and secured with adhesive tape, since we have started knotting the drawstrings together no further cases have occurred in our hospital. Bilateral packing is important as even the insertion of 3 fingerstall packs on one side does not prevent posterior dislocation as was observed in one of our own cases. No cases of dislocation of expandable packs have been reported.

In the case of the various types of stents and spacers attention must be paid that they are secured by anchoring rings or sutures. The tubes in particular are always at risk of dislocation and aspiration can never be entirely ruled out. Castillo et al. (1996) reported on complications occurring in 553 patients who had undergone endoscopic paranasal sinus surgery and mention one death on account of incorrect placement of a frontal sinus drain. Unfortunately more precise details are not given.

2.3. Disturbance of breathing during sleep or decrease in nocturnal arterial PO2

There are a number of investigations showing that complete nasal obstruction by bilateral nasal packing leads to increased disturbances of breathing during sleep (Lavie et al., 1983, Suratt et al., 1986; Taasan et al., 1981; Wetmore et al., 1988) and decreases the nocturnal arterial PO2 (Cassisi et al., 1971; Cook and Komorn, 1973; Johannessen et al., 1992; Kalogjera et al., 1995, Lin and Orkin, 1979; Slocum et al., 1976; Zwillich et al., 1981). The effects range from a decrease in the oxygen partial pressure only detectable by laboratory testing (Buckley et al., 1991) to sleep apnoea (Wetmore et al., 1988). The risk appears to be increased particularly in elderly patients with primary cardiac and pulmonary disease. In these cases duration of packing should be shortened and/or intensive monitoring (pulsoximetry) is recommended. However, some authors were unable to demonstrate any effect (Serpell et al., 1994) while others question the clinical relevance of the findings (Buckley et al., 1991).

2.4. Influence on eustachian tube function

There are some reports on a dysfunction of the eustachian tube with significant reduction in the middle ear pressure during or after packing of the nose according to the Toynbee phenomenon (Egelund and Jeppesen, 1992; Finkelstein et al., 1988; Morgan et al., 1995; Thompson and Crowther, 1991). Ventilation tubes had inconsistent effects. There was no permanent influence of nasal packing on the function of the eustachian tube.

A temporary reduction of the pressure in the middle ear will resolve spontaneously.

2.5. Allergy

The reasons for the marked increase of latex-rubber allergy are still unclear. The widespread use of latex gloves may play a role, as may the use of new latex preparations with greater allergenicity, increased awareness and improved diagnostic methods. On the basis of their investigations Lundberg et al., (1997), regard the move from talcum to starch powder as a further reason. They were able to show that although talcum powder binds latex allergens to a considerably greater extent this binding is very stable. Starch powder, on the other hand, binds latex allergens to a lesser extent but rapidly releases them into aqueous solution. In principle, induction of allergy by latex packing is possible. The likehood of triggering an allergic reaction probably depends to a great extent on the quality of the product. At the ENT departments in Fulda and Magdeburg no cases of induction of allergy by nasal packing have been observed during 15 years' use in about 500 patients per year. The manufacturers of the Rhinotamp fingerstall packs have had no reports of

Table 5. Complications in packing the nose

Complication	Mainly caused by (packing material)	Prevention	Therapy
Severe mucosal lesion	Pneumatic balloon, (gauze)	Avoid balloons, reduce pressure, reduce packing duration	
Dislocation, aspiration	Fingerstalls, gauze	Correct fixation	Removal
Obstructive sleep apnoea syndrome	All	Take care in older patients and in patients with cardiac and pulmonary disease, Monitoring (pulsoxymetry)	Remove packing, Reduce packing duration
Eustachian tube dysfunction	All	No packing	Resolves spontaneously
Allergy	Latex fingerstalls	No packing	Removal
Toxic shock syndrome	All	Not possible	Removal, antibiotics, intensive care
Paraffin granuloma	Packing with ointment	Avoid ointment in case of periorbital injury	Surgical (very difficult)

Table 6: Clinical signs of the toxic shock syndrome

Temperature > 38.9°C
Diffuse macular or maculopapular rash
Desquamation of palms or soles 1-2 weeks after onset
Hypotension (systolic blood pressure ≤ 90 mmHg, orthostatic drop in pressure of > 15 mm Hg, syncope)
Clinical or biochemical involvement of at least 3 organ systems
No other identifiable cause

allergies in latterly about 120,000 packs used per year (Harren, personal communication). Nevertheless, first fingerstalls without latex are on the market, using a polyurethane covering (Spiggle&Theis, Dieburg, Germany).

2.6. Toxic Shock Syndrome (TSS)

The toxic shock syndrome is a rare, acute multisystem disease which is characterised by a sudden onset with high fever, diffuse rash, vomiting, diarrhoea and muscle pain and can lead to septic shock (Table 6; Younis and Lazar, 1996; Todd et al., 1978). It is a complication of a staphylococcal infection triggered by toxic shock syndrome toxin I (TSS I). While most cases of toxic shock syndrome were seen in young, healthy, menstruating women using vaginal tampons, most of the remaining cases of TSS were in the head and neck region particularly in connection with preceding nasal surgery. Jacobson and Kasworm (1986) reported an incidence of TSS after nasal surgery of 16.5 per 100,000 for the state of Utah. TSS after nasal surgery usually occurs within the first 24 hours and is associated with the use of nasal packing, but TSS can develope several days to weeks after surgery and in patients where no nasal packing was used (Abram et al., 1994; Younis and Lazar, 1996). TSS has been reported in association with a number of different packing materials (Allen et al., 1990; Breda et al., 1987; Hull et al., 1983; Mansfield and Petersen, 1989; Toback and Fayerman, 1983) and also with the use of splints (De Vries and van der Baan, 1989; Jacobson and Kasworm, 1986; Wagner and Toback, 1986).

TSS cannot be predicted or prevented by e.g. antibiotics (Jacobson and Kasworm, 1986; Jacobson et al., 1988). Decisive are early diagnosis, immediate and sufficient therapy: removal of the foreign body, drainage of the site of infection, a penicillinase resistant antistaphylococcal antibiotic and intensive care are essential components of the treatment. Corticosteroids may be able to reduce the severity and duration of the TSS.

2.7. Paraffin granulomas and spherulocytosis

Chemically, paraffins are alkanes, that is saturated acyclic hydrocarbons, although in the narrower sense the term paraffin refers to the solid alkanes. Paraffins are commonly used as ingredients of ointment formulations but not of gel formulations. When paraffin or similar substances containing alkanes are injected into tissue typical lipogranulomas or paraffinomas develop after latency periods varying from a few weeks to several years.

For diagnosis of a paraffinoma after endonasal paranasal sinus surgery the following conditions must be fulfilled (Keerl et al., 1995; Weber et al., 1995):

1. Intraoperative injury to the periorbita indicated by the presence of a postoperative periorbital haematoma.
2. Use of a paraffin-containing ointment formulation in the context of packing of the operative cavity.
3. Histological demonstration of a paraffinoma or additional detection using special stains or NMR spectroscopy (Geiger et al., 1993).

It presents clinically as a firm swelling which slowly increases in size. The histology shows a giant-cell rich foreign body granuloma. Numerous large cavities of various sizes are typical and are produced by removal of the paraffin-containing material during deparaffination. In addition, tissue reactions occur around the cavities. The intraoperative finding of diffuse spread of the granuloma into the soft tissue with poor delineation can also be demonstrated histologically. Surgery is the only appropriate therapy. However, on account of the diffuse infiltration surgical removal was very difficult and revision surgery was required in all patients. In view of the increasing reports of paraffin granulomas in the periorbital region after paranasal sinus surgery (Geiger et al., 1993; Hintschich et al., 1995; Tasman et al., 1994) paraffin-containing ointments or creams should not be used at the end of paranasal sinus operations if periorbital injury has occurred.

Periorbital injury can be easily identified intraoperatively with the help of the eyeball pressure test according to Draf (Weber and Draf, 1992). In the case of such injury a packing material which slides easily without additional use of an ointment should be positioned instead of gauze. Moreover, it is not yet clear whether the antibiotic additives contained in most of the ointments recommended for this purpose do in fact prevent bacterial infection of the nasal and paranasal mucosa.

Spherulocytosis or *myospherulosis* describes a tissue reaction occurring after use of antibiotic-containing ointments in wounds and musculature (Godbersen et al., 1995; Wheeler et al., 1980; McClatchie et al., 1969). The histology is characterised by dilated cystic spaces of varying size which are surrounded by histiocytes and occasionally by multinuclear giant cells. It has been reported as foreign body reaction to various antibiotic ointments and is interpretated as the consequence of a physical emulsion phenomenon between fat-containing material and blood (Kakizaki and Shimada, 1993; Godbersen et al., 1995). There is evidently a close relationship between spherulocytosis and paraffin granuloma.

2.8. Infections caused by nasal packing

Up to now there is no proof that antibiotics reduce the rate of infections in patients with nasal packing. In a prospective randomised placebo-controlled study Derkay et al. (1989) investigated 20 patients who had received posterior nasal packing with antibiotic impregnated gauze because of nosebleeds. No infections occurred either in the placebo group or in the group treated with cephazoline. Although antibiotic administration in posterior nasal packing is recommended in the literature there is allegedly insufficient proof of its effectiveness (Hirsch, 1987). Packs which do not contain antibiotics show colonisation with various gram-negative bacteria (Herzon, 1971). Nigam and Allwood (1990) investigated the antibacterial activity of BIPP packing against *Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeruginosa.*

They found that BIPP packing had only negligible antibacterial activity. Further, no release of iodine from BIPP packing was found during a 4-week period. The authors were unable to explain the discrepancy between the clinical effectiveness and the lack of antibacterial activity in vitro. The evident effectiveness may be due to the careful surgical debridement and wound cleansing, the BIPP packing in fact only acting as haemostatic pack.

Schäfer and Pirsig (1988) investigated the effect of prophylactic antibiotic therapy with 3 million units of propicillin orally for 12 days in 100 patients undergoing revision septorhinoplasty (active drug in 48 patients, placebo in 52 patients). Six patients developed severe infections, 5 of them in the placebo group, 12 patients developed more localised infections, 9 of them in the placebo group. The authors concluded that postoperative administration of propicillin appears to prevent severe nasal infections particularly when free grafts have been used.

In summary, if there are no special risk factors antibiotics are not indicated during nasal packing of several days. It has not proven that postoperative infections increase with the use of nasal packing. Furthermore it has not proven that antibacterial additives to nasal packing are effective.

2.9. Pain caused by nasal packing

Some investigations showed significant pain and discomfort related to the packing (Nunez and Martini, 1991; Pringle et al., 1996; Samad et al., 1992; Tierney et al., 1996). Others described evidence of less pain in patients with nasal packing (Friedman et al., 1996; Thomas et al., 1996).

As the postoperative removal of the nasal packing is considered the most unpleasant part of the nasal operation (Guyuron and Vaughan, 1995; Mauriello and Vedehra, 1996; Samad et al., 1992; Von Schoenberg et al., 1993) some studies were conducted to examine how this could be made less painful, using 5% lignocaine ointment (Kuo et al., 1994), intramuscular administration of 10 mg papaverine and inhalation of Entonox (50 % nitrous oxide and 50 % oxygen) (Laing and Clark, 1990), or 4% lignocaine solution (Lavy et al., 1996).

In summary, normal nasal packing does not cause significant postoperative pain in most patients. Removal of the packing is the most unpleasant part of the operation for many patients. Removal of gauze packing is by far the most painful.

2.10. Further rare complications (case reports)

- Fracture of the lamina papyracea by nasal packing for epistaxis (Oluwole and Hanif, 1996). In this case a posterior Foley balloon catheter was inserted followed by tight anterior nasal packing. The patient developed exophthalmus with double vision and impaired vision which were reversible after removal of the packing.
- Velopharyngeal perforation (Streitmann and Frable, 1996).
- Granuloma pyogenicum after packing with paraffin gauze for epistaxis (Sheen et al., 1997; Bhattacharyya et al., 1997).
- Acute airway obstruction in a patient with anterior nasal packing for epistaxis and acute dystonia with abnormal tongue movements as side-effect of a neuroleptic (Pinczower and Rice, 1990).
- BIPP induced methaemoglobinaemia (Nigam et al., 1991). In an investigation in 10 patients before and 24 hours after packing with BIPP abnormal methaemoglobin levels were only found in one patient. This patient had received a large amount of BIPP packing after bleeding from an angiofibroma (Nigam et al., 1991). Nevertheless the authors report that methaemoglobinaemia is still in principle a risk, particularly as BIPP is the most commonly used form of packing in the United Kingdom.

3. WHICH PACKING MATERIALS AND STENTS SHOULD BE USED?

A packing material or stent for use in endonasal surgery should ideally have the following characteristics:

- non-toxic
- non-allergenic
- no foreign body reaction
- no spontaneous dislocation
- easy insertion
- easy removal
- no patient discomfort or pain
- adaptability to the individual anatomy (haemostasis, wound healing)
- even exertion of pressure on the mucosa
- positive influence on postoperative wound healing
- no impairment of breathing
- no impairment of olfaction

When evaluating the suitability of the various packing materials for endoscopic surgery to the nose or paranasal sinuses their influence on wound healing should be given particular attention (Weber et al., 1996a,b). A packing material has a positive influence on wound healing if it

I. does not cause additional traumatisation whether through irritation, toxicity, foreign body reaction or injury on removal,
II. creates a moist environment,
III. prevents the wound surfaces from sticking together,
IV. helps prevent later stenosis due to scar tissue.

I. Traumatisation occurs if the regenerating tissue grows into the packing material so that epithelium and granulations are torn away when the packing is removed, leading to bleeding and renewed induction of a repair process (Kühnel et al., 1996). The minimum pore size which allows ingrowth of tissue is considered to be 20-50 μm, which is the size required for migration of macrophages (Constantino et al., 1993). It was shown in an animal study that bone growth into porous polyethylene occurred at a pore size of 40 μm (Klawitter et al., 1976). Rubber fingerstalls were shown to be impermeable to viruses and bacteria (Gerhardt, 1989; Zbitnew et al., 1989) and are thus also impermeable to granulation tissue. Gauze and uncoated large-pore foam packing materials do not meet this requirement.

II. A moist wound environment promotes wound healing and is achieved with an occlusive dressing: epithelialisation is accelerated, the inflammatory reaction and development of necrosis in the early stage are suppressed and scar formation in the late stage reduced (Alvarez, 1987; Bolton et al., 1992; Falanga, 1988; Helfman et al., 1994; Hinman and Maibach, 1963; Winter, 1962). The positive effect is achieved by stopping the tissue from drying out and thus preventing secondary damage (Bothwell et al., 1972; Winter and Scales, 1963).

III. - IV. After operative enlargement, there are three partially interconnected ways in which restenosis of the nasofrontal duct can occur (Weber et al., 1997):

a. Through persisting blockage of the duct with blood and fibrin immediately postoperatively. In the proliferative phase of wound healing beginning on the 2nd-3rd postoperative day fibroblasts migrate into the fibrin mesh and granulation tissue forms. Finally collagen is deposited, leading to formation of scar tissue and occlusion.
b. Through pronounced swelling beginning in the third postoperative week leading to zones of contact with adjacent or opposed areas of the nasofrontal duct. In the case of either primary absence of epithelialisation or secondary epithelial damage due to pressure-related maceration or inflammatory cell damage tissue bridges form between the opposed areas of granulation tissue. Here too the end result is occlusion by scar tissue.
c. Through re-orientation of collagen fibres in the remodelling phase beginning in the third postoperative week (Kischer and Shetlar, 1974; Bailey et al., 1975). The fibres form so-called scar diaphragms on concave surfaces as the distance can only be shortened by utilising the free lumen, bony remodelling of scars or diaphragms has also been shown (Hilding 1933 a,b; Hilding and Banovetz, 1963). Ring-shaped openings can thus become concentrically narrowed. The process takes months to years with declining activity (Levenson et al., 1965; Madden and Peacock, 1968, 1971; Verzar and Willenegger, 1961). Insertion of a stent e.g. into the frontal sinus neo-ostium allows epithelialisation to take place along the device. The subepithelial scar layer can stabilise. In order to be effective the stent must therefore remain in situ for several months. Six months appears to be appropriate and sufficient, like experiences with the insertion of Montgomery tubes in tracheal surgery. After this 6-month period renewed stenosis is considerably less likely to occur than if the stent is only left in for 2-3 weeks.

To sum up, on the basis of the available data we will now attempt to evaluate the various packing materials with regard to their fulfilment of the criteria described above and their consequent indications (Table 7):

Gauze: the concrete properties of gauze packs depend largely on the additives used. Gauze alone is rarely used in the nose. Its insertion already causes marked irritation of the mucosa. Ointments added to improve handling carry the risk of allergies to the vehicles, antibiotics (neomycin!) or other ingredients. Further, there is the risk of toxicity of additives and the development of paraffin granulomas if ointment penetrates into the surrounding soft tissue, e.g. after periorbital injury. Dislocation is in principle possible although removal of the packing is then relatively easy and dramatic emergencies seldom occur.
The mesh structure leads to marked tissue ingrowth and significant traumatisation on removal, which causes pain (Garth and Brightwell, 1994; von Schoenberg et al., 1993; Pringle et al., 1996) and bleeding and has an unfavourable influence on wound healing. The technique of insertion of strips permits adaptation to the individual anatomy but exerts uneven pressure on the mucosa with the risk of excessive local pressure and consequent necrosis. The complete occlusion of the nose permits neither breathing nor smelling.
Altogether ribbon gauze packing in endonasal surgery should be abandoned in favour of better alternatives.

Rubber fingerstalls, though non-toxic, theoretically carry the risk of latex allergy although this has not yet been found to be clinic-

Table 7: Properties of nasal packing materials. + = meets criterion; +/- = partly meets criterion; - = does not meet criterion

Property criteria	Gauze without ointment	Gauze with ointment	Telfa	Rubber fingerstalls	Stents	Foam	Foam (coated)
Non-toxic	+	- (ointment?)	+	-		+	-
Non-allergenic	+	+ - (ointment)		+/-	+/-	-	-
No foreign body reaction	-	-		+	+/-	-/-	+
No spontaneous dislocation	-		-	- + (regular application)	+/-		+
Easy insertion	-	+/-	+	+	+/-	+/-	+
Easy removal	-	-	+	+	+	-	+
Patient comfort	-	-	+/-	+	+ - (crusting, smell)	-	+
Adaptable to individual anatomy		-	-	-	-	+/- (fixed size)	-/- (fixed size)
Uniform pressure on mucosa	-	-	-	-	-	+	
Favourable influence on postoperative wound healing	-	-	+/-	-	-	-	
Unimpaired breathing	-	-	-	-	- (in event of crusting or protrusion into the nose)	- (ventilation tubes often become blocked)	- (ventilation tubes often become blocked)
Unimpaired olfaction	-	-	-	-	+/-	-	-

ally relevant. On account of their non-adherent surface they are easy to insert and remove and cause little patient discomfort. Wound healing is positively influenced by the occlusive dressing. The soft, malleable structure exerts even pressure on the mucosa. Complete obstruction of the nose permits neither breathing nor smelling. Because of its favorable properties we use rubber fingerstalls very often.

Foam packs are suitable for control of bleeding on account of their swelling properties which allow sufficient adaptation to the individual anatomy. Their limitations are the inalterable size and shape of the tampons. If the pores are too large they allow ingrowth of granulation tissue with the disadvantageous consequences of difficult removal, bleeding and unfavourable influence on wound healing. Dislocation of the expanded tampons does not appear to be possible. Insertion of ventilation tubes in principle permits breathing. However, the pressure of the surrounding tampon and the tendency to crusting with blood or secretions not infrequently eliminates this effect. The complete obstruction of the nose permits neither breathing nor smelling.
Stents and spacers are left in the paranasal sinus region for prolonged periods. They are usually made of well tolerated silicone although on account of the longer time left in situ development of mild to moderate oedema is almost always seen. As crusts can form on the surface they can cause patient discomfort due to an unpleasant smell or impairment of nasal breathing. The ease of insertion and the possibility of spontaneous dislocation depend to a large extent on the design of the model used.

For *septal surgery* packing is only necessary in order to prevent a postoperative septal haematoma. A non-adherent pack is suitable for this. However, septum splints or special suturing techniques can also be used.
In *turbinate reduction procedures* such as conchotomy there is usually heavier bleeding from the wound surfaces so that pressure is required to control bleeding. It is also desirable to promote healing of the open wound. On account of the open wound surface non-adherent packing materials should be used, possibly in addition to splinting in the case of simultaneous septal surgery. Or the ventilation tube of the Doyle splint can act as a non-adherent pack. As the packing is usually only left in situ for a few hours or at most a few days an influence on wound healing is scarcely possible. In this case patient comfort is a more important aspect. Removal should not be painful and should not usually cause bleeding.
In *paranasal sinus surgery* the influence on wound healing is an increasingly important aspect. Here, too, only non-adherent materials should be used. Depending on the extent of the procedure and the desired direct influence on surgically created ostia various stent systems can be considered. At present the

outcome appears to be influenced less by the concrete type of stent than by the duration of stenting. The long term results with regard to prevention of restenosis are better the longer the stent is left in situ. The desirable duration is 6 months.

Packing materials with pore sizes greater than 50 μm in principle carry the risk of ingrowth of granulation tissue. However, this process is also influenced by further material properties such as cytotoxicity or antichemotaxis. The crucial factor influencing ingrowth is the tissue-material interaction in the form of adhesion and the possibility of promotion on the material. There have been no relevant investigations of this to date.

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